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Certificate of Accuracy of Translation

The undersigned,

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certifies:

- (1) I am fully conversant with both the English and the Japanese languages;
- (2) I have translated into English:

Japanese patent application number 9-314867 ("Shaft for light-weight golf clubs")

- (3) The translation is, to the best of my knowledge and belief, an accurate translation from the original into the English language.

The undersigned declares further that all statements made herein of his own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the matter with which this translation is used.

7/19/01
Date

Massato Otsuka
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Translator



[Document name] Specification

[Name of the invention] Shaft for light-weight golf clubs

[Claims of the invention]

[Claim 1] A light-weight golf club shaft formed by laminating a plurality of layers of fiber-reinforced composite material comprising, in sequence from the inner layer: a first angled layer; a first straight layer; a second angled layer; and a second straight layer; said layers extending over the entire length of said shaft and including fiber-reinforced composite material; wherein: said second angled layer has a thickness of 0.04 - 0.1 mm, and reinforcing fibers contained therein have a orientation of 60 - 75 degrees relative to the longitudinal direction of said shaft; and said shaft has a torsional strength of at least 120 N * m * degrees, a crushing strength of at least 10 kg/10 mm, and a weight of 30 - 45 g.

[Claim 2] A light-weight golf club shaft as recited in claim 1 wherein: the thickness of said first angled layer at a small-diameter end of said shaft is twice that of said first angled layer at a large-diameter end of said shaft.

[Detailed description of the invention]

[0001]

[Technical field of the invention]

The present invention relates to a shaft for golf clubs (hereinafter referred to simply as shaft). More specifically, the present invention relates to a shaft that is 35-50 percent lighter than conventional shafts while providing the same outer diameter and the same characteristics of conventional shafts such as flexural rigidity, flexural strength, torsional rigidity, torsional



strength, and crushing strength.

[0002]

[Background technology]

In one type of golf club shaft, a fiber-reinforced composite material (hereinafter referred to as FRP) is used. A "one-directional" preimpregnation is formed by lining up reinforcing fibers and then immersing them in resin. This is then wrapped around a tapered metal core and hardened in this laminated state. This type of golf club shaft is widely used due to its high specific rigidity, specific strength, and the degree of freedom allowed in its design.

[0003]

FRP shafts often use a two-layer structure consisting of an inner angled layer and a straight layer. In the angled layer, preps are glued together so that the reinforcing fibers form angles of $+\theta$, $-\theta$ relative to the longitudinal axis of the shaft. In the straight layer, the preps are stacked so that the reinforcing fibers are within a ± 20 degree range relative to the longitudinal axis of the shaft. The angled layer and the straight layer referred to in the present invention are based on this definition as well.

[0004]

In recent years, there has been a trend toward lightening the shaft in order to provide a larger sweet spot to accompany higher head speeds, longer shafts, and larger heads.

[0005]

Conventionally, this was accomplished simply by reducing the number of straight layers and angled layers that make up the shaft. However, this also reduced flexural rigidity, flexural strength, torsional rigidity, torsional strength, and crushing strength.

[0006]



One method for providing a lighter shaft while maintaining flexural rigidity and torsional rigidity involves: (1) reducing the number of straight layers and/or angled layers while also using a reinforcing fiber that has a high elasticity in these layers; (2) reducing thickness by changing the shape of the shaft itself, primarily by increasing the outer diameter.

[0007]

In method (1), the flexural rigidity and torsional rigidity is comparable with conventional shafts. However, reinforcing fibers with high elasticity generally have low strength, and this results in flexural strength and torsional strength that would be the same as or even lower than when the number of layers is simply reduced. In method (2), increasing the outer diameter near the grip is effective in maintaining flexural rigidity, but this makes the shaft difficult to handle, making the arrangement impractical.

[0008]

Japanese laid-open utility model publication number 62-33872 discloses a method for improving the torsional rigidity and torsional strength in FRP shafts. In this method, an FRP shaft including angled layers and straight layers is formed with an angled layer as the outermost layer. However, with this method, the finishing process, i.e., polishing and the like, of the FRP shaft can result in the loss of the angled layer, which is needed to maintain torsional rigidity and torsional strength. Thus, the FRP shafts do not have consistent quality and a lighter FRP shaft is not provided.

[0009]

[Problems to be solved by the invention]

The object of the present invention is to overcome the problems described above and to provide a shaft that is 35 - 50% lighter than conventional shafts while maintaining the outer

diameter and characteristics of conventional shafts such as flexural rigidity, flexural strength, torsional rigidity, and torsional strength.

[0010]

[Means for solving the problems]

The present invention provides a light-weight golf club shaft formed by laminating a plurality of layers of fiber-reinforced composite material. The following layers are formed in sequence starting with the inner layer: a first angled layer; a first straight layer; a second angled layer; and a second straight layer. These layers extend over the entire length of the shaft and contain fiber-reinforced composite material. The second angled layer has a thickness of 0.04 - 0.1 mm, and reinforcing fibers contained therein have an orientation of 60 - 75 degrees relative to the longitudinal direction of the shaft. The shaft has a torsional strength of at least 120 N * m * degrees, a crushing strength of at least 10 kg/10 mm, and a weight of 30 - 45 g.

[0011]

[Embodiments of the invention]

There are no special restrictions on the reinforcing fiber used in the FRP of the light-weight shaft of the present invention, and any reinforcing fiber that is used in standard FRPs can be used. Examples include organic reinforcing fibers such as high-strength polyethylene and para- aromatic polyamides, as well as inorganic and metal fibers such as carbon fibers, glass fibers, boron fibers, silicon carbide fibers, alumina fibers, and Tyranno fibers. In the present invention, the reinforcing fibers do not necessarily need to be partially or entirely comprised of high-elasticity reinforcing fibers as described in the conventional technology.

[0012]

There are no special restrictions on the matrix resin used in the FRP for the light-weight



shaft of the present invention and any resin for standard FRP matrix resins can be used.

Generally, thermosetting matrix resins such as epoxy resins, unsaturated polyester resins, vinyl ester resins, polyimide resins, and polybismaleimide resins are used. Of course, thermoplastic resins can be used for the matrix resin without changing the essence of the present invention.

[0013]

The fiber-reinforced composite material used in the shaft is generally formed with a "prepreg" formed by lining up the reinforcing fiber described above and immersing them in the matrix resin. There are no special restrictions on the thickness, fabric weight, the resin content, or the like, and these factors can be chosen according to the needed thickness of the layers and the wrapping diameters.

[0014]

The light-weight shaft according to the present invention has a main structure containing four layers. Starting with the inner layer, these are: a first angled layer, a first straight layer, a second angled layer, and a second straight layer. In order to reduce weight while maintaining the shaft characteristics and outer diameter, as well as to maintain balance for a high torsional strength, the second angled layer should have a thickness of 0.04 - 0.1 mm, and the reinforcing fibers contained therein should be oriented at 60 - 75 degrees relative to the longitudinal axis of the shaft. It would be desirable, in terms of having a high crushing strength, for the orientation angle to be at 65 - 70 degrees.

[0015]

Of course, as long as the object of the invention can be achieved, layers can be added in addition to the first and second straight layers and the first and second angled layers for the purpose of reinforcing the end, matching diameters, and the like.

[0016]

There are no special restrictions on the thickness of the first angled layer as long as the thickness is a standard value generally seen in FRP shafts. However, a value of 0.2 - 0.4 mm would be desirable to prevent longitudinal cracking during withdrawal of the metal core, which serves as the mold during production.

[0017]

Of course, the thickness does not have to be uniform over the entire length of the shaft. As long as the objects of the invention, i.e., the flexural rigidity, flexural strength, torsional rigidity, torsional strength, and crushing strength, are not sacrificed, the thickness can be designed as desired to improve other characteristics. For example, it would be possible to have the thickness of the first angled layer at the small-diameter end of the shaft be twice the thickness of the large-diameter end.

[0018]

There are no special restrictions on the thicknesses of the first straight layer and the second straight layer as long as the total thickness is comparable with the thickness of the straight layers in standard two-layer shafts. In general, the total thickness is 0.2 - 0.4 mm. The respective thicknesses of the first and second straight layers can be set on the basis of the flexural rigidity, the flexural strength, and the like of the FRP shaft, and it would be acceptable to have both layers formed with the same thickness.

[0019]

In terms of providing the FRP shaft with appropriate flexural rigidity and flexural strength, it would be desirable to provide the first and the second straight layers with thicknesses of 0.1 - 0.2 mm and 0.1 - 0.2 mm respectively, providing a total layer thickness of 0.2 - 0.4 mm.

[0020]

In order to provide a light-weight shaft without changing the shaft characteristics and outer diameter, as in the objects of the present invention described above, the thickness of the second angled layer must be 0.04 - 0.1 mm. Also, the reinforcing fibers therein must be oriented at 60 - 75 degrees relative to the longitudinal axis of the shaft in order to maintain a crushing strength of 10 kg/mm.

This type of thin second angled layer can be implemented by using a very thin prepreg (having a thickness of 0.05 mm or less) with a fiber weight of 18 - 55 g/m², or more desirably 18 - 30 g/m². For example, the HRX330M025S from Mitsubishi Rayon Corp. Ltd. (25 g/m² prepreg fabric density, 45% resin content, 0.025 mm thickness), or the MR340K020S can be used for easy implementation.

[0021]

[Embodiments]

The following is a detailed description of the embodiments of the present invention. The fiber angles referred to below are angles measured relative to the longitudinal orientation of the shaft.

[0022]

(Prepreg)

Table 1 shows the prepgs used in this embodiment.

[0023]

[Table 1]

[0024]

(Measuring torsional strength and torsional rigidity)

Torsional tests were performed according to the golf club shaft certification standards and standards confirmation method as set forward by the Institute for Product Safety (approved by the Minister of International Trade and Industry, 5 Industry, Number 2087, October 4, 1993).

[0025]

The small-diameter end of the shaft was fixed and torque was applied to the large-diameter end. Using the 5KN universal tester from Mechatronics Engineering Corp. Ltd., the torsional strength was measured when the shaft broke due to torsion.

[0026]

(Flexural strength)

A point T on the shaft (90 mm from the small-diameter end), a point A (175 mm from the small-diameter end), a point B (525 mm from the small-diameter end), and a point C (175 mm from the large-diameter end) were used to determine strength by performing a three-point bending test with a span of 300 mm (150 mm for T only). The penetrator was set to 75 mmR and the support was set to 12.5 mmR.

[0027]

(Measuring crushing strength)

Compression tests were performed using a universal compression tester. Test pieces roughly 10 mm in length and centering on a point a (10 mm from the large-diameter end of the shaft), a point b (100 mm from the same), a point c (200 mm from the same), and a point d (300 mm from the same) were prepared and tested for strength.

[0028]

(Measuring flexural rigidity)

Flexure was measured by stabilizing the large-diameter end of the shaft and a 1 kg load

was applied at a position 10 mm from the small-diameter end.

[0029]

(Embodiment 1)

A tapered metal core having an outer diameter of 5.25 mm at the small-diameter end, an outer diameter of 14.05 mm at the large-diameter end, and a length of 950 mm is used. As described in (1) - (7) below, around this metal core are formed, in sequence, a 90 degrees reinforcing layer, a first angled layer, a first straight layer, a second angled layer, a second straight layer, and an end-reinforcing layer.

[0030]

(1) Prepreg is wrapped around the metal core at a fiber orientation of 90 degrees. A prepreg D is sheared at the small-diameter end and the large-diameter end to form a single layer that is roughly trapezoidal in shape. This is wrapped around the metal core to form the 90-degrees reinforcing layer.

[0031]

(2) Prepreg is wrapped around the metal core to form a fiber orientation of +45 degrees. A prepreg A is sheared so that there are two layers at the small-diameter end and one layer at the large-diameter end. Another prepreg A is sheared so that this same arrangement occurs when it is wrapped at a fiber orientation of -45 degrees. These prepgs are adhesed together so that these fiber orientations intersect. The adhesed prepgs are then wrapped around the metal core to form the first angled layer.

[0032]

(3) Prepreg is wrapped around the first angled layer at a fiber orientation of 0 degrees. A prepreg B is sheared so that a single layer is formed at both the small-diameter end and the large-

diameter end. This is then wrapped over the single angled layer to form the first straight layer.

[0033]

(4) Prepreg is wrapped over the first straight layer at a fiber orientation of +70 degrees. A prepreg C is sheared to form a single layer at both the small-diameter end and the large-diameter end. Another prepreg C is sheared so that the same arrangement is formed when it is wrapped around at a fiber orientation of -70 degrees. These prepregs are adhesed together so that these fiber orientations intersect, and the adhesed prepregs are wrapped over the first straight layer to form the second angled layer.

[0034]

(5) Prepreg is wrapped over the second angled layer to form a fiber orientation of 0 degrees. A prepreg E is sheared so that a single layer is formed at both the small-diameter end and the large-diameter end. This is then wrapped over the second angled layer to form the second straight layer.

[0035]

(6) Prepreg is wrapped over the second straight layer to form a fiber orientation of 0 degrees. A prepreg E is sheared in a roughly trapezoidal shape so that a single layer is formed at the small-diameter end as well as a position 300 mm from the small-diameter end. This is then wrapped over the second straight layer to form an end-reinforcing layer.

[0036]

(7) Prepreg is wrapped over the end-reinforcing layer to form a fiber orientation of 0 degrees. A prepreg F is sheared in a roughly triangular shape so that the outer diameter of the small-diameter end is 8.5 mm. This is then wrapped over the end-reinforcing layer to form a layer for adjusting the outer diameter of the small-diameter end.

[0037]

A polypropylene tape having a width of 20 mm and a thickness of 30 microns is wrapped over these layers at a 2 mm pitch. This is then hardened for 240 minutes in a curing oven.

[0038]

The polypropylene tape is then removed and the metal core is withdrawn. 10 mm are cut off from both the small-diameter end and the large-diameter end to provide a shaft weighing 37 g, having a length of 1145 mm, an outer diameter at the small-diameter end of 8.5 mm, and an outer diameter at the large-diameter end of 15.0 mm. The resulting shaft has the characteristics shown below.

[0039]

Flexural rigidity: 70 mm

Flexural strength: point T 120 kgf, point A 60 kgf, point B 55 kgf, point C 55 kgf

Crushing strength: 12 kg/10 mm

Torsional rigidity: 5.5 deg

Torsional strength: 150 N m deg

[0040]

(Comparative example 1)

(1) A 90-degree reinforcing layer as in (1) of embodiment (1) was formed.

(2) A first angled layer as in (2) of embodiment (1) was formed.

(3) A first straight layer as in (3) of embodiment (1) was formed.

(4) Prepreg is wrapped over the first straight layer to form a fiber orientation of +20 degrees. A prepreg C is sheared so that a single layer is formed at the small-diameter end and the large-diameter end. Another prepreg C is formed so that the same occurs when the fiber

orientation is -20 degrees. These preps are then adhesed so that the fiber orientations intersect. The adhesed preps are wrapped around the first straight layer to form the second angled layer.

(5) A second straight layer is formed as in (5) of the first embodiment.

(6) An end-reinforcing layer is formed as in (6) of the first embodiment.

(7) A layer for adjusting the diameter of the small-diameter end is formed as in (7) of the first embodiment. These are then hardened as described in embodiment 1 to form a shaft weighing 37 g and having a length of 1145 mm, an outer diameter of 8.5 mm at the small-diameter end, and an outer diameter of 15.0 mm at the large-diameter end. The resulting shaft has the characteristics shown below.

[0041]

Flexural rigidity: 70 mm

Flexural strength: point T 120 kgf, point A 60 kgf, point B 40 kgf, point C 40 kgf

Crushing strength: 6 kg/10 mm

Torsional rigidity: 5.5 deg

Torsional strength: 120 N m deg

[0042]

(Comparative example 2)

A shaft is formed in the same manner as in embodiment 1 except the second angled layer is eliminated, and the number of layers of preps A, which have fiber orientations of +45 degrees and -45 degrees, is 2.1 at the small-diameter end and 1.1 at the large-diameter end. The resulting shaft weighs 37 g and has a length of 1145 mm, an outer diameter of 8.5 mm at the small-diameter end, and an outer diameter of 15.0 mm at the large-diameter end. This shaft has the characteristics shown below.

[0043]

Flexural rigidity: 70 mm

Flexural strength: point T 100 kgf, point A 50 kgf, point B 35 kgf, point C 35 kgf

Crushing strength: 4 kg/10 mm

Torsional rigidity: 5.6 deg

Torsional strength: 100 N m deg

[0044]

[Advantages of the invention]

The present invention provides a shaft that is 35-50 percent lighter than conventional shafts while providing the same outer diameter and the same characteristics of conventional shafts such as flexural rigidity, flexural strength, torsional rigidity, torsional strength, and crushing strength.